FORESTRY
ECONOMIC & REGIONAL
DEVELOPMENT AGREEMENT

FORÊT
ENTENTE DE DÉVELOPPEMENT
ÉCONOMIQUE ET REGIONAL

MANITOBA FORESTRY DEMONSTRATION AREAS

Canada

Manitoba

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INTRODUCTION

From 1870 to 1930, before the jurisdiction for forestry was transferred from the federal to the provincial government, Manitoba's forests were controlled and administered by the Dominion of Canada. Reforestation planting trials were established by the federal government in the first decade of the century and other research work in forestry followed. Since that time numerous studies in all areas of forest management have been implemented throughout the province by the federal and provincial governments, industry and private individuals.

Under the Canada-Manitoba Forest Renewal Agreement signed in 1984, several demonstration areas have been selected from among the many research studies that demonstrate certain management objectives and silvicultural prescriptions applicable for Manitoba forests, and quite possibly a variety of other Canadian forest management circumstances. Each area is described by a short paper, giving the historical background or methods employed and the current results. Each report contains a map showing the geographic location of the area and, wherever necessary, a more detailed plot map. Signs in the field identify the area as a forest management demonstration area, and within each area appropriate plot signs are placed.

The **Demonstration Manual and Notes** will serve as a means of technology transfer for the operational forester and the public. New demonstration areas will be selected and notes added to the manual as measurements are completed and compiled.

FOREST MANAGEMENT
DEMONSTRATION NOTE NO. 1

White Spruce Transplant Stock Grading Increases Yields, 59 Years After Planting

In 1927, five-year-old (2-3) white spruce seedlings were graded into smaller and larger planting stock and two separate plantations were established on the Audy Lake Plain of Riding Mountain National Park (Fig. 1). The plantations are located on a gentle undulating outwash plain that is about 1 km by 3 km in area. The A soil horizon is a structureless black loam fine sand, 18 cm to 46 cm thick; the B, when present, is a clay loam usually less that 13 cm thick. (Haig, 1958) The parent material is a sand loam with a high gravel and lime content. The moisture regime and pore pattern are rated as 1 (Hills, 1952).

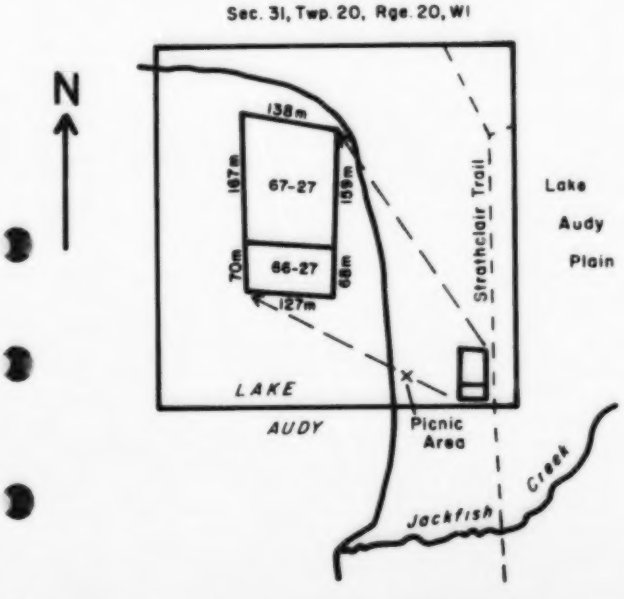


Figure 1. Location of plantations 66-27 and 67-27.

The area was burned to remove the heavy grass cover and prairie herbs, and furrows were ploughed in an east-west direction just prior to planting. In 1985 these furrows were still readily visible. The smaller stock was set out in plantation 66-27 and the larger stock in 67-27. The seedlings were planted on the south side of the furrows during the last week of May, 1927.

In 1957, survival in the plantations was very patchy; some areas were fully stocked while others had no survivors. On the south side of plantation 66-27 there was a large open area. In 1985, this open area, and similar but smaller patches within the two plantations, was well stocked with vigorous and healthy white spruce 2 m or more in height. These young trees were established by natural seeding from the plantations. Haig gave the following reason for the patchy survival: The furrows ploughed in 1927 were about 25 cm deep; this depth, in places, removed the entire A horizon. The seedling was then planted directly on the parent material. The parent material lacking nutrients and with a high lime content and low moisture holding capacity was detrimental to survival. Outside of these patches, plantation survival is excellent. Walking between the planted rows is made difficult by the dead branches that persist on the trees. Lesser vegetation is very sparse or non-existent beneath the trees and a carpet of needles covers the ground.

Severe white pine weevil damage had occurred in the plantations by 1945. In 1957 about 5% leader mortality was noted and the incidence of multiple leaders, crooks, and double stems indicated continued weevil attacks in preceding years. By 1957 the plantation established from the larger stock had an average advantage of 2.3 cm in diameter and 0.73 m in height over the plantation established from the smaller stock (Table 1). In 1985 the plantations were remeasured to determine if this advantage in diameter and height had continued. The open patches with no surviving planted trees amounted to 32% and 22% of the respective area sampled in plantations 66-27 and 67-27. However, no adjustment was made for these open areas in calculating the per hectare value of basal area or total volume.

Survival differences between the two plantations have been negligible, but substantial growth benefits have resulted from planting larger transplant stock (Table 1). The diameter difference between the two plantations in 1957 had remained relatively constant to 1985, but the difference in mean plantation height had increased. Fifty-nine years after planting, the plantation established from the larger stock is 1.5 cm greater in diameter and 2.4 m in height than the plantation established from the smaller stock. Basal area in

TABLE 1. White spruce plantation development as affected by stock grading, 59 years after planting, 1927-1985

	Plantations								
	66-27 Smaller (2-3 stock)				67-27 Larger (2-3 stock)				Difference (Larger – smaller)
Year of measurement	1928	1945	1957	1985	1928	1945	1957	1985	1985
Area (ha)		0.87				2.15			
No. planted/ha (1927)		2715				2812			
% survival	81	41	33	30	98	45	33	37*	7
Mean diameter (cm)	—	7.4	11.4	19.3	—	7.4	13.7	20.8	1.5
Mean height (m)	0.18	4.3	6.8	13.1	0.34	4.9	7.5	15.5	2.4
Basal area (m^2/ha)	—	—	9.2	24.5	—	—	13.7	35.8	11.3
Total volume (m^3/ha)**	—	—	32.6	149.2	—	—	53.4	243.1	93.9

* Survival increase from 1957 to 1985 resulted from different sampling lines.

**Table 150 (Dom. For. Serv., 1948).

plantation 67-27 is currently 46% greater than in plantation 66-27; in 1957 it was 49% greater. Total volume advantage for plantation 67-27 was 64% and 63% greater in 1957 and 1985, respectively.

References:

Dom. For. Serv., 1948. Form-class volume tables. 2nd ed. Can. Dept. Mines and Res.

Haig, R.A. 1958. Reforestation by planting, Riding Mountain National park. Can. Dep., Nor. Aff. and Nat. Res., For. Br., For. Res. Div., Unpubl.

Hills, G.A. 1952. The classification and evaluation of site for forestry. Ont. Dep. Lands For., Div. Res., Res. Rpt. No. 23.

N.R. Walker
D.R. Witt
June, 1987

FOREST MANAGEMENT
DEMONSTRATION NOTE NO. 2

Elk and Moose Browsing Prevents The Growth of A New Trembling Aspen/Balsam Poplar Forest

In November 1968, scarification trials were carried out in Riding Mountain National Park to promote natural regeneration through suckering of old deteriorating trembling aspen and balsam poplar stands (Fig. 1). The work took place on the former experimental area administered by the Canadian Forestry Service (Pratt, 1970). About 6.5 ha were treated by scalping strips with a bulldozer blade. Each bulldozed-scalped strip was about 3.6 m wide and this alternated with an untreated strip of equal width. The treatment removed the A soil horizon and the dense hazel understory. Prior to treat-

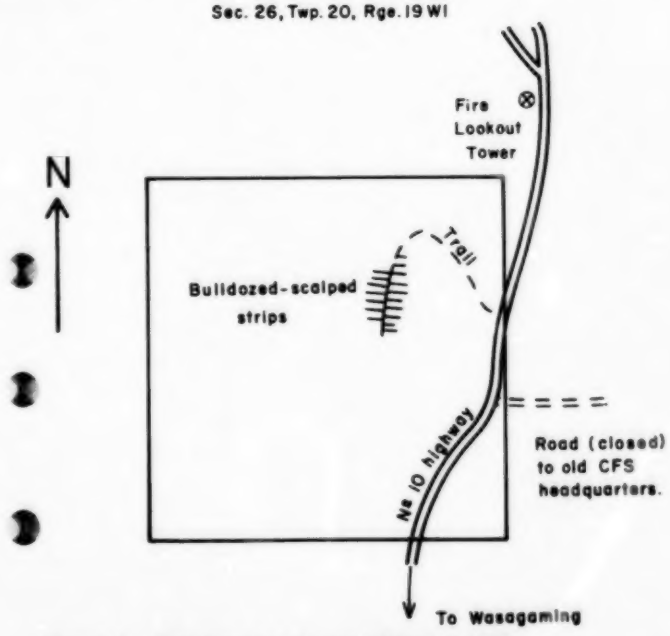


Figure 1. Plot location of area treated in 1968.

TABLE 1. Number and basal area of residual (old growth) trees ≥ 2.5 cm dbh

	1968		1986	
Species	No. of trees/ha	Basal area m^2/ha	No. of trees/ha	Basal area m^2/ha
White spruce	116	2.3	94	5.3
Trembling aspen and balsam poplar	254	14.0	62	2.7
White birch	62	4.0	21	1.3
Total	432	20.3	177	9.3

TABLE 2. Trembling aspen and balsam poplar regeneration on bulldozed-scalped strips

	1969			1986			
	No. quadrats[a]	% stocking	Density per ha	No. quadrats[b]	% stocking	Density per ha	Height m[c]
Bulldozed	525	93	48 311	96	71	4 217	1.17
Not bulldozed	not tallied			96	67	3 913	1.21
Mean					69	4 065	1.19

a 4.05 m^2
b 10 m^2
c 92% of regeneration browsed

TABLE 3. Stocking and density of beaked hazel on bulldozed-scalped and unbulldozed strips in 1986

	No. quadrats[a]	% stocking	Density per ha
Bulldozed	12	100	115 833
Not bulldozed	11	100	125 454
Mean		100	120 435

a 1 m²

ment, the area had an average of 67 aspen and 10 balsam poplar suckers per hectare. The number of residual trees on the area that were 2.5 cm and greater in diameter in 1968 and in 1986, is given in Table 1.

The bulldozed-scalping operation to promote trembling aspen and balsam poplar regeneration was very successful (Table 2). In 1969, one year after treatment, stocking on the scalped area was 93% and density was 48 311 stems per hectare. In 1986, mean stocking and density was still satisfactory at 69% and 4 065 stems per hectare, respectively. New suckering was still taking place. The treatment promoted suckering on the unscalped area as readily as it did on the scalped area ($P > 0.001$).

Severe browsing by elk and moose occurs each year and the mean height of the regeneration 18 years after treatment is only 1.19 m. Currently only 8% of the regeneration is unbrowsed and these have escaped damage only because of their current low height. Repeated browsing on juvenile trees more than 2 cm dbh ultimately results in mortality of the sapling.

Beaked hazel has readily regenerated on the scalped strips. There was no significant difference ($P > 0.001$) in hazel density between the treated and untreated strips and the average is 120 435 stems per hectare (Table 3). Observations show that the elk and moose browse the hazel as readily as the trembling aspen and balsam poplar regeneration.

The treatment employed has successfully regenerated the area to trembling aspen and balsam poplar suckers. Repeated and severe browsing by elk and moose, however, has prevented the growth of the new forest.

References:

Pratt, R.H.M. 1970. Silvicultural Operations, Riding Mountain Forest Experimental Area 1969. Dep. Fish. For., Can. For. Serv., For. Res. Lab., Wpg. Man., Int. Rpt. MS-106

N.R. Walker
June, 1987

FOREST MANAGEMENT
DEMONSTRATION NOTE NO. 3

White Spruce Sawlogs Produced 68 Years After Planting

From 1918 to 1929, eleven white spruce plantations were established near the northeast boundary of Riding Mountain National Park (Fig. 1). By 1957, only one of those plantations (4-18) contained surviving trees (Haig, 1958). The failure of the plantations is attributable to snowshoe hare browsing, suppression by aspen overstory, and mechanical destruction by elk. A history of plantation 4-18 to 1985 follows. This is to show what might have been achieved through plantation management and what has acutally occurred as a result of neglect.

The plantation is located on a bench of post-glacial Lake Agassis. The soil parent material is a waterworked fine sand; the profile was described by Haig:

A0 – 5cm of needle litter
A1 – 4cm of black loam

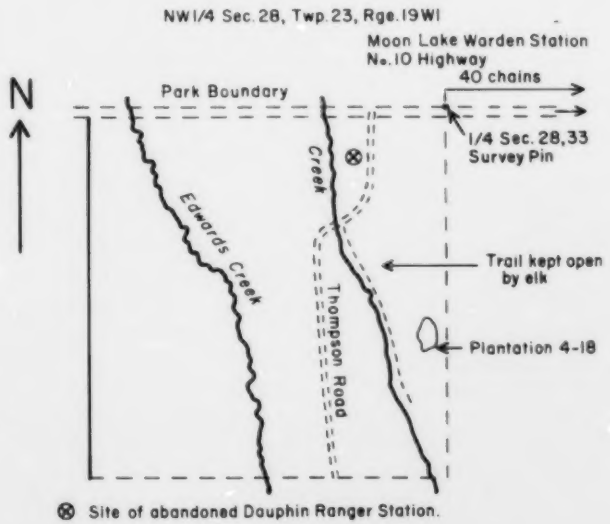


Figure 1. Location of plantation 4-18.

A2 – 13 cm of grey-brown sand
B – 48 cm of buff colored structureless sand
C – buff colored structureless sand

The moisture regime is rated as 4 and pore pattern 2 (Hills, 1952). The area is considered to be a high quality site for growing white spruce. It had previously been occupied by a stand of aspen with a continuous understory of hazel. The aspen was cut for cordwood and the slash was burned. The area was then planted to five-year-old white spruce transplants during the last week of April, 1918. Density within the plantation was 5906 seedlings ha on a 0.37 ha area.

Eight growing seasons after planting (in 1925) survival was 82%. Two years later it was only 51% (Table 1). During this two year period the mean plantation height was reduced by 0.12 m. The rapid increase of mortality and the reduction in mean height was attributed to browsing by snowshoe hares. In 1927, approximately 27% of the dominant and all of the suppressed trees were damaged by browsing.

In 1929, aspen from suckers had reoccupied the area; density was 3632 stems/ha with a mean height of 4.88 m (Table 2). The largest spruce then was 3.38 m and whipping damage was occurring on the plantation.

By 1957, aspen density was estimated at 494 stems/ha with diameters ranging from 10 cm to 25 cm, and heights from 14 m to 17 m. Some of the spruce was severely suppressed by the aspen overstory. At the same time, severe damage caused by elk removing the velvet from their antlers, was noted on almost all spruce trees in the plot. Damage was in the form of long narrow slashes, resembling fire scars, that had cut away the bark and cambium. The rapid drop in survival to only 4% was in part attributed to this damage.

In 1985, elk damage was still occurring and old scars were noted on spruce trees as large as 39 cm in diameter. Trees up to 23 cm in diameter had recently been killed.

The plantation is surrounded by an aspen forest with a dense understory of hazel and scattered amounts of red-osier dogwood, cranberry, chokecherry and mountain maple. There is, however, no shrub understory within the stand. The lack of a secondary understory makes the area particularly attractive to elk and it is heavily used.

Apsen within the plantation still overtops a number of spruce trees. These are severely suppressed and the tops may be dam-

TABLE 1. Survival and growth of plantation 4-18

Year of measurement	1920	1921	1922	1923	1924	1925	1927	1929	1957	1985
Growing seasons after planting	3	4	5	6	7	8	10	12	40	68
Survival %	90	88	86	86	84	82	51	48	4	3
Average height (m)	—	0.61	0.73	0.94	1.22	1.37	1.25	1.58	11.95	19.04
Average diameter (cm)	—	—	—	—	—	—	—	0.76	18.29	28.45

TABLE 2. Trembling aspen ingress into plantation 4-18

Year of measurement	1929	1957	1985
Density (stems/ha)	3 632	494	252
Average height (m)	4.88	15.50	20.85
Average diameter (cm)	—	17.50	23.11

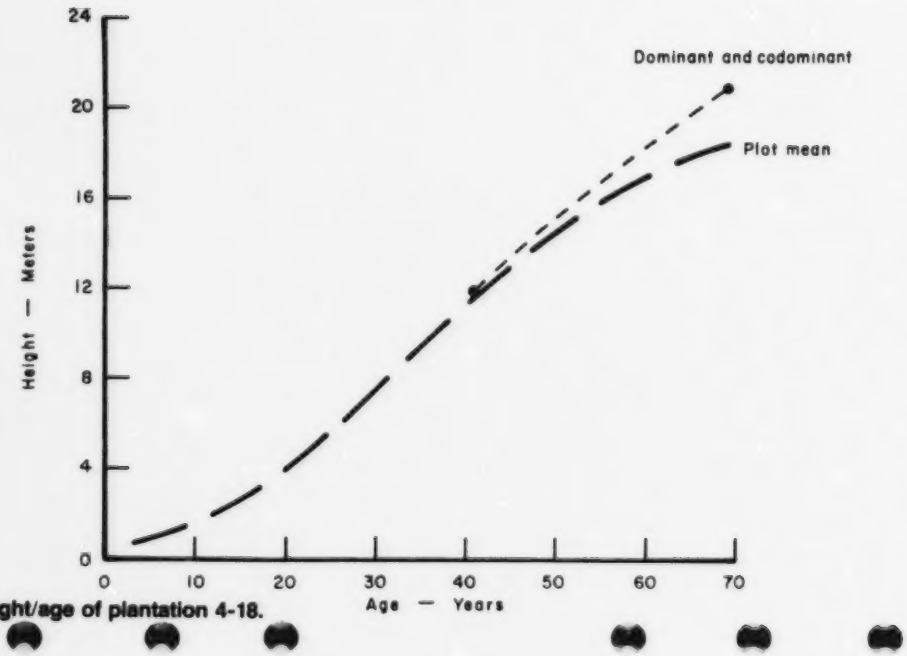


Figure 2. Height/age of plantation 4-18.

aged. Aspen density is 252 stems/ha, mean height 20.8 m, and mean diameter 23.1 cm.

Current survival of the white spruce plantation is only 3%, mean height 19 m, and mean diameter 28 cm (Fig. 2). The mean height and diameter of 17 dominant and codominant trees, unaffected by suppression, is 21 m and 35 cm respectively. Height and diameter ranges are 17 m to 24 m and 24 cm to 51 cm, respectively. This shows that with control of such damaging agents as snowshoe hares and elk, and with the timely removal of a suppressing aspen overstory, this site can produce sawlogs in less than 70 years from planting.

References:
Haig, R.A. 1958. Reforestation by planting. Riding Mountain National Park. Can., Dep. Nor. Aff. Nat. Res., For. Br., For. Res. Div., Unpubl.
Hills, G.A. 1952. The classification and evaluation of site for forestry. Ont., Dep. Lands For., Div. Res., Res. Rpt. No. 24.

N.R. Walker
D.R. Witt
June, 1987

FOREST MANAGEMENT
DEMONSTRATION NOTE NO. 4

Post-Burn Interval Does Not Enhance Direct Seeding or Planting Survival of Jack Pine

Prescribed burning as a method of site and seedbed preparation for seeding and planting of jack pine was first used in the Sandilands Provincial Forest of southeastern Manitoba in 1964. Regeneration following seeding and planting of burns without further site preparation, has shown varied results (Cayford, 1966). In cases where initial germination and planting was satisfactory, subsequent drought and high soil surface temperatures caused heavy seedling mortality. Delaying seeding or planting to allow for vegetation development and for weathering of burned seedbeds to ameliorate the site was considered to be one possible solution to the problem.

On August 25, 1967 the Manitoba Department of Mines and Natural Resources prescribed burned 12ha of a 19ha jack pine cutover from the previous winter (Figs. 1 and 2). The high intensity

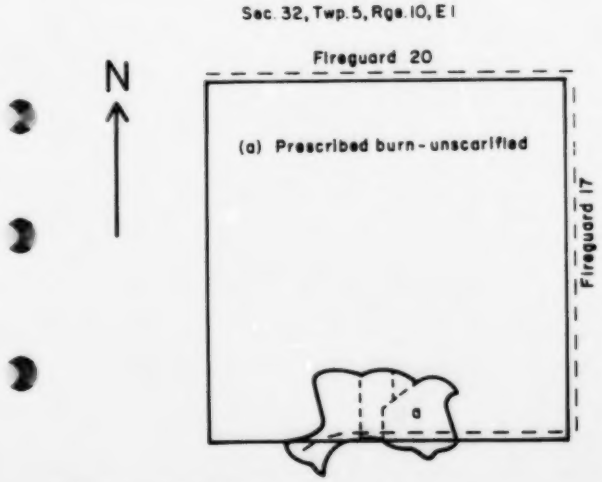
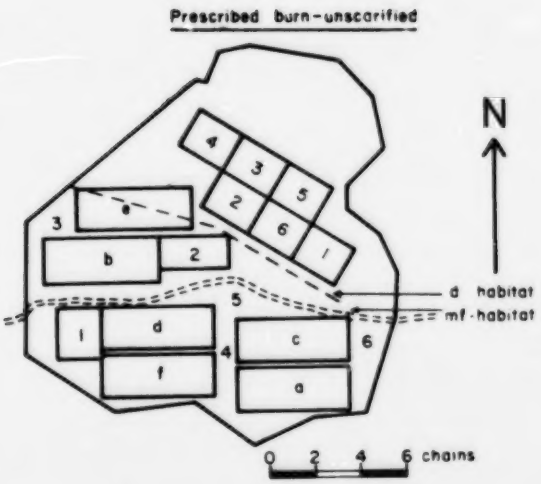


Figure 1. Study area.



Time of treatment	Seeding	Planting
Fall 1967	a	1
Spring 1968	b	2
Fall 1968	c	3
Spring 1969	d	4
Fall 1969	e	5
Spring 1970	f	6

Figure 2. Prescribed burn area showing planted and seeded plots.

fire consumed the organic horizons and resulted in more than 75% mineral soil exposure. Fall and spring seeding and planting was then carried out on the area for three consecutive years. Seeding with a Cyclone hand seeder at a rate of 841 g/ha took place on 0.40 ha plots. Planting (2-0 or 3-0 stock, Table 1) was carried out at 1.8 x 1.8 m spacing in rectangular plots of 500 seedlings. Planting took place on two habitat types, d (dry) and mf- (mesotrophic moderately fresh), (Mueller – Dombois, 1964). The d habitat type is nutritionally poor and affected by drought during the growing season, while the mf- is nutrionally intermediate with favorable soil moisture.

Spring planting, whether on the dry or fresh habitats, was always successful and no benefit was obtained by delaying planting for

TABLE 1. Planting stock description

Planting date	Stock age	Length		Oven dry weight		Shoot/root ratio
		Top cm	Root cm	Top g	Root g	w/w
October 24–26, 1967	2-0	16.8	26.2	3.16	0.97	3.26
May 1–3, 1968	2-0	17.3	16.8	1.76	0.47	3.74
Sept. 30–Oct. 2, 1968	2-0	23.1	20.1	3.19	0.70	4.56
April 21–23, 1969	3-0	24.9	24.1	4.29	0.35	12.26
Sept. 24–26, 1969	3-0	32.0	24.6	7.75	1.62	4.78
May 7, 1970	2-0	13.2	43.4	4.56	1.20	3.80

TABLE 2. The effect of a post-burn interval and season of planting on jack pine establishment – results to 1985

Yrs. Since Burn	Time of Planting	FALL % Survival	FALL $\bar{Ht.}$ (m)	FALL $\bar{Diam.}$ (mm)	SPRING % Survival	SPRING $\bar{Ht.}$ (m)	SPRING $\bar{Diam.}$ (mm)
d (dry) habitat							
1	1967-68	46	4.8	60	70	5.5	65
2	1968-69	50	4.5	57	65	5.6	70
3	1969-70	14	4.1	57	89	3.2	35
	Average	26	4.5	58	75	4.8	57
mf- (moderately fresh) habitat							
1	1967-68	52	5.9	82	86	6.5	76
2	1968-69	<27	4.4	55	75	7.0	84
3	1969-70	<13	No data	No data	83	6.2	83
	Average	—	5.5	67	81	6.6	81

* Acceptable plantation survival ≥ 70% after two years: Manitoba forest regeneration survey manual (1980).

TABLE 3. The effect of a post-burn interval and season of seeding on jack pine establishment – results to 1985

Yrs. Since burn	Time of seeding	FALL				SPRING			
		% Stocking	No. /ha	$\bar{H}t.$ (m)	$\bar{D}iam.$ (mm)	% Stocking	No. /ha	$\bar{H}t.$ (m)	$\bar{D}iam.$ (mm)
1	1967-68	100	9 000	7.6	86	100	17 000	7.0	68
2	1968-69	80	4 750	6.3	79	95	8 000	6.4	77
3	1969-70	65	1 500	4.5	58	90	6 000	6.0	80

two to three years after the burn (Table 2). Fall planting on both habitats resulted in failures or was only marginally successful during the first and second year.

No advantage was gained in delaying seeding for two or three years after burning (Table 3). Seedling density and stocking per hectare was greatest for the first year of treatment and declined progressively during year two and year three. Spring seeding produced better results than fall seeding and only in the fall treament of the third year was there a failure.

In view of the results obtained, prescribed burns of jack pine cutovers should not be planted in the fall. They should be planted in the spring following the burn as no additional survival advantages are obtained as a result of further delay. Past studies have shown, however, that planting in mechanically prepared furrows on prescribed burns will increase spring planting survival (Walker, 1967).

Spring seeding has produced an unnecessarily high density but this may be changed by reducing the amount of seed sown per unit area. Spring seeding should always be favored over fall seeding due to the greater probability of success (Cayford 1961, Walker and Sims, 1984). However, seeding of prescribed burns should be approached with caution in spite of the success of this study, since Cayford (1966) and Walker and Dobbs (1968) have reported failures from 1964 to 1967 on similar studies.

References:

Cayford, J.H. 1961. Broadcast seeding jack pine at weekly intervals in Manitoba. Can. Dep. For., For. Res. Branch, Tech. Note 106.

Cayford, J.H. 1966. Some aspects of jack pine regeneration on prescribed burned areas. Bi-Monthly Research Notes. Vol. 22, No. 5.

Mueller-Dombois, D. 1964. The forest habitat types of southeastern Manitoba and their application to forest management Can. J. Bot. 42:1417-1444.

Walker, N.R. 1967. The use of prescribed burning in jack pine management in southeastern Manitoba Dep. For. Rural Dev., Can. For. Serv., For. Res. Lab., Wpg., Man., Int. Rpt. MS-49.

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N.R. Walker
June, 1987

FOREST MANAGEMENT
DEMONSTRATION NOTE NO. 5

Naturally Regenerated Jack Pine Has Improved Stem Form

On August 25, 1967 the Manitoba Department of Natural Resources prescribed burned 12 ha of a larger 19 ha jack pine cutover logged the previous winter in the Sandilands Provincial Forest in southeastern Manitoba. More than 75% mineral soil exposure was obtained by the high intensity burn. Between September 26 and October 4, 4 ha of the burn and the 7 ha unburned portion were scarified with shark-finned barrels, anchor chains, or a combination of the two. (Figs. 1 and 2). The burn and subsequent scarification provided an opportunity to compare three methods of site preparation for artificial seeding and planting of jack pine: (1) burned, (2) burned-scarified, (3) unburned-scarified, and a fouth method, (4) natural seeding on unburned-scarified.

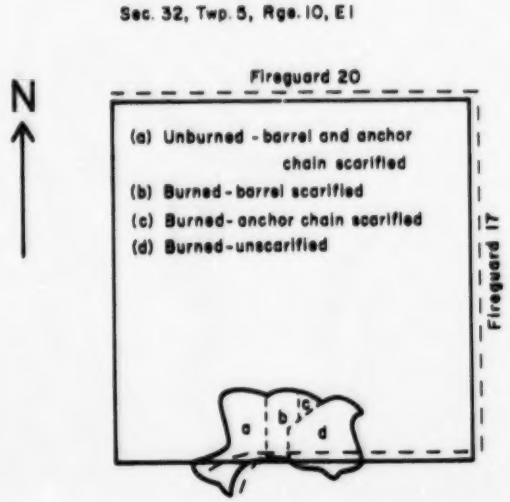


Figure 1. Study area showing site treatments.

In the fall of 1967 and in the spring of 1968, the four site prepared areas were seeded or planted to jack pine. Seeding was carried out with a Cyclone hand seeder on 0.40 ha plots at a rate of 841 g/ha. Planting (2-0 stock, Table 1) was carried out at 1.8 x 1.8 m spacing in rectangular plots of 500 seedlings. On the scarified portion, seedlings were planted in the furrows made by the barrels. The area left for natural regeneration was treated with barrels and anchor chains. Slash on the area was windrowed during logging and the barrels were pulled parallel to the windrows. The chains were then pulled at right angles to the barrelled furrows to drag the slash over the barrelled area.

Spring planting, regardless of site treatment was always successful and has produced a high rate of stocking (Table 2). Fall planting, though, was always less successful. Burning followed by barrel scarification improved fall planting survival on the comparable habitats but it was not always beneficial for spring planting. Similar studies carried out in 1964 have demonstrated positive survival advantages when seedlings were planted in mechanically prepared furrows on prescribed burns (Walker, 1967). Scarification prior to planting created a more favorable microsite and improved survival by removing the blackened surface layer caused by the burn, and by forming a catchment area for rain and snow.

Burning improved growth by making the nutrients on the area available for immediate seedling use. Fall planted trees on the moderately fresh (mf-) site of the burn are 0.8 m to 1.0 m taller than trees on the unburned. Spring planted trees on the mf- site of the burn are 1.1 m to 1.2 m taller than trees on the unburned.

Both spring and fall seeding on all site treaments, on either habitat, dry or fresh, resulted in full stocking with a large number of trees per hectare (Table 3). Natural seeding brought about by barrel and anchor chain scarification produced a stocking rate of 94% and 6142 stems per hectare. Fall seeding on the mf- site of the burn has produced seedlings that are currently 1.3 m to 1.6 m taller than natural or artificial fall seedlings on the unburned.

Direct seeding has resulted in an unnecessarily high density ranging from 9000 to 19250 stems per hectare and this may ultimately affect growth. Trees on the natural seeded area have better stem form than those produced by planting and the optimum density has reduced branch diameters. In view of the results obtained, scarification to promote natural regeneration on fresh sites should be favored over artificial seeding or planting. It will reduce costs and result in better stand development.

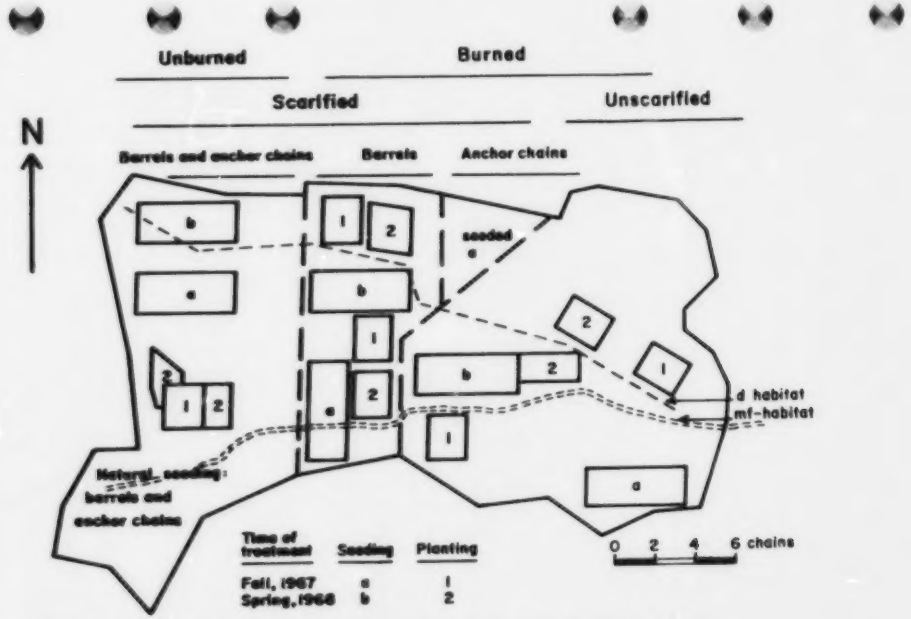


Figure 2. Study area showing site treatments with planted and seeded plots.

TABLE 1. Planting stock description

Planting date	Stock age	Length		Oven dry weight		Shoot root ratio
		Top cm	Root cm	Top g	Root g	w w
October 24–26, 1967	2-0	16.8	26.2	3.16	0.97	3.26
May 1–3, 1968	2-0	17.3	16.8	1.76	0.47	3.74

TABLE 2. The effect of season and three site treatments for planting of jack pine – results to 1985

	FALL (1967)				SPRING (1968)			
Treatment Method	Habitat*	% Survival**	$\bar{Ht.}$ (m)	$\bar{Diam.}$ (mm)	Habitat	% Survival*	$\bar{Ht.}$ (m)	$\bar{Diam.}$ (mm)
1. Burned	d	46	4.8	60	d	70	5.5	65
1. Burned	mf-	52	6.9	82	mf-	86	6.5	76
2. Burned – scarified (barrels)	d	55	5.9	74	d	80	5.9	61
2. Burned – scarified (barrels)	mf-	71	7.1	86	mf	81	6.4	80
3. Unburned – scarified (barrels)	mf-	56	6.1	78	mf-	69	5.3	71
Average		56	6.2	76		78	5.9	71

* Mueller-Dombois, D. 1964
(mf-) mesotrophic moderately fresh
(d) dry

** Acceptable plantation survival ≥ 70% after two years: Manitoba forest regeneration survey manual (1960).

TABLE 3. The effect of season and four site treatments on artificial and natural seeding of jack pine – results to 1985

	FALL (1967)					SPRING (1968)				
Treatment Method	Habitat	% Stocking	No./ha	$\bar{Ht.}$ (m)	$\bar{Diam.}$ (mm)	Habitat	% Stocking	No. ha	$\bar{Ht.}$ (m)	$\bar{Diam.}$ (mm)
ARTIFICIAL SEEDING										
1. Burned	mf-	100	9 000	7.6	86	mf-	100	17 000	7.0	68
2. Burned – scarified (barrels)	mf-	100	13 000	7.3	74	mf-	100	17 000	7.2	66
2. Burned – scarified (anchor chains)	d	100	18 000	5.8	54					
3. Unburned – scarified (barrels)	mf-	100	11 000	6.0	66	d	100	19 250	4.4	46
NATURAL SEEDING										
4. Unburned – scarified (barrels & anchor chains)	mf-	94	6 142	6.0	73					

References:

Mueller-Dombois, D. 1964. The forest habitat types of southeastern Manitoba and their application to forest managment. Can. J. Bot. 42:1417-1444.

Walker, N.R. 1967. The use of prescribed burning in jack pine managment in southeastern Manitoba. Dep. For. Rural Dev., Can. For. Serv., For. Res. Lab. Wpg., Man. Int. Rpt. MS-49.

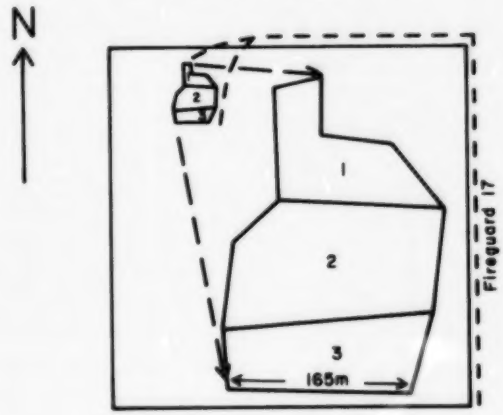
N.R. Walker
June, 1987

FOREST MANAGEMENT
DEMONSTRATION NOTE NO. 6

Barrel and Chain Scarification Promotes Successful Jack Pine Regeneration in Southeastern Manitoba

Jack Pine cutovers in the Sandilands Forest Reserve were scarified with barrels and anchor chains to promote natural regeneration from slash-borne seed in 1968 and 1969 (Hennessey, 1970). The open-dense, mature stands were located on fresh, sand textured soils. Slash on the cutovers was piled in windrows, and in some blocks, windrowing was more pronounced then in others (Figs. 1 and 2). On four blocks (2,3,4, and 6) barrel scarification took place between the windrows, and anchor chain-treatment was carried out at right angles to the barrelled furrows to drag the slash

Sec. 29, Twp. 5, Rge. 10, E1



1. Anchor chained
2. Barrel and anchor chained
3. Barrel and anchor chained (well windrowed slash)

Figure 1. Location of area treated in 1968.

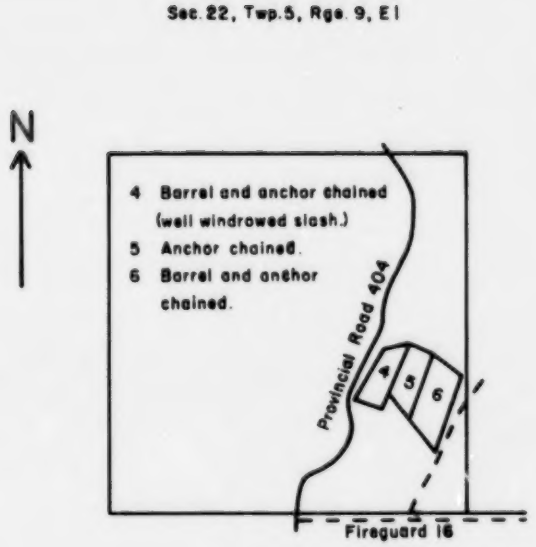


Figure 2. Location of area treated in 1969.

with its cone bearing seed over the barrelled area. Two blocks (1 and 5) scarified only with anchor chains were treated with two passes of the chains at right angles to each other.

Blocks 1 and 2 on Sec. 29, Twp. 5, Rge. 10 E are currently well stocked (Table 1). Block 3 with the well windrowed slash is a failure. Blocks 4 and 5 on Sec. 22, Twp. 5, Rge. 9 E are failures as well. Block 4, however, was again a well windrowed area. The north ¾ of Block 6 is satisfactorily stocked. The south ¼ of the block, is not satisfactorily stocked to jack pine but well stocked to trembling aspen.

The success of these two years of treatment show that anchor chain, or, a combination of barrel and anchor chain scarification, on fresh, sand textured jack pine cutovers is a successful forest renewal technique to obtain natural regeneration (also refer to Walker, 1987). This treatment would be assured of even greater success without the practise of slash windrowing and the consequent removal of the seed supply.

TABLE 1. Natural Regeneration of jack pine cutovers – results to 1985

Block Treatment	Date scarified	Jack Pine				Trembling Aspen	
		% Stocking	No. /ha	$\bar{Ht}$. m.	$\bar{Diam}$. mm	% Stocking	No. /ha
		Sec. 29, Twp. 5, Rge. 10E.					
1. Anchor chains	May 23, 1968	83	3 500	5.9	72	33	1 500
2. Barrels and anchor chains	May 23, 1968	76	12 000	5.7	65	19	<500
3. Barrels and anchor chains (well windrowed area)	May 24, 1968	46	<500	5.2	72	15	<500
		Sec. 22, Twp. 5, Rge. 9E.					
4. Barrels and anchor chains (well windrowed area)	June 25, 1969	39	250	4.0	51	24	<250
5. Anchor chains	July 3, 1969	39	3 000	3.6	41	34	400
6. Barrels and anchor chains north ¾ of block	June 27, 1969	83	3 200	4.0	44	37	600
Barrels and anchor chains (south ¼ of block)	June 27, 1969	33	1 666	4.4	48	67	6 333

References:
Hennessey, G.R. 1970. Scarifying cutover jack pine stands with barrels and anchor chains, Manitoba and Saskatchewan. Dep. Fish. For., Can. For. Serv., For. Res. Lab., Wpg., Man., Int. Rpt. MS-104.
Walker, N.R. 1987. Naturally regenerated jack pine has improved stem form. Can.-Man. Eco. Reg. Dev. Agreement. For. Mgmt. Demo. Note No. 5.

N.R. Walker
June, 1987

FOREST MANAGEMENT
DEMONSTRATION NOTE NO. 7

Regular Spacing Increases Merchantable Volume in White Spruce

A white spruce plantation established as a farm shelterbelt using, it is believed, wildling transplants, was planted by a pioneer family in the Grandview District of western Manitoba in about 1902 (Fig. 1). One hundred and eighty-six seedlings were originally planted.* Presently the plantation consists of nine rows of trees with twenty per row, at regular 3.0m intervals, on a 0.17ha area. Some refill planting took place in the centre of the plantation in later years but the present size of these trees, in terms of height and diameter, equals that of the original stems and shows that their impact on plantation survival and development was negligible. Later, six of the 180 trees were removed from the east side of the planatation due to their interference with the farm home. The stand is presently past maturity and volume is being lost through decay. There are a few dead standing trees and a number of others have been removed for firewood.

* Personal communication from Mrs. Mildred Jeffrey, former land owner and pioneer.

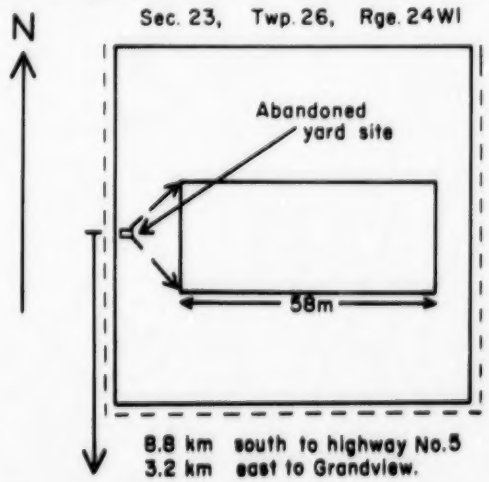


Figure 1. Location of plantation.

TABLE 1. Stand statistics in 1986 of the Grandview white spruce plantation (per ha values)

Number of trees	% Survival (1902-86)	Mean diameter cm	Mean height m	Basal area m^2	Volume Total[a] m^3	Volume Merch.[b] m^3
1064	72	27.9	20.8	47.3	429	397

a Table 150 (Dom. For. Serv., 1948).
b Table 24 (Kabzems, 1971).

TABLE 2. Periodic radial increment at stump height

	Age – years						
	0-10	11-20	21-30	31-40	41-50	51-60	61-70
Trees within stand (N = 5)							
Inc. (cm)	2.9	3.3	3.1	1.7	1.7	0.9	0.7
Trees on outside rows (N = 2)							
Inc. (cm)	1.9	3.2	3.4	3.0	2.5	1.6	1.6

The trees have excellent form, and within the stand, dead limbs up to 2 cm in diameter persist to ground level. Live branches begin at about the ten metre level. The absence of lower limbs on some trees indicates that some hand pruning had taken place. Minor vegetation consists primarily of scattered rose shrubs. Young aspen, 1-2 m tall, have regenerated on about one-quarter of the plantation along the northwest side. The plantation is located on flat terrain and it is immediately adjacent to a cultivated field to the south side. The soil is grey wooded derived from till of limestone and granitic rock with loam to clay loam textures (Ehrlich et al, 1959).

In 1986 the plantation was measured to determine survival and volume. With consideration given to the very symmetrical 3.0 m spacing, 180 live, dead, or missing trees can be accounted for. Trees along the four outside rows are noticeably larger in diameter but not in height. For this reason a bias occurs towards a larger mean plantation diameter, but it is felt that inclusion of these trees more accurately reflects the true potential of the site with intensive management. Increment cores taken at stump height gave a mean age of 80 years.

Plantation survival to 1986 is 72% (Table 1). Mean diameter and height is 27.9 cm and 20.8 m, respectively, with corresponding ranges of 14.7 cm to 49.3 cm for diameter and 16.76 m to 25.39 m for height. Stump height core measurements show that diameter growth of trees within the stand declined between 21-30 years (Table 2). Diameter growth of trees along the outside rows decreased between 31-40 years. On an individual tree basis 50% or more of the total diameter growth occurred within the first 30 and 40 years for trees within the stand and on the outside rows, respectively.

With a total age of 90 years and a mean height of 20.8 m the plantation corresponds to an average site of natural well stocked white spruce stands in Saskatchewan (Kabzems, 1971). However, because of the regular spacing and the larger tree diameters this plantation contains 33% more basal area and 49% more merchantable volume than corresponding natural stands.

References:
Dom. For. Serv., 1948. Form-class volume tables. 2nd ed. Can. Dep. Mines and Resour.
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Kabzems, A. 1971. The growth and yield of well stocked white spruce in the mixedwood section in Saskatchewan, Sask., Dep. Nat. Res., For. Br., Tech. Bull. No. 5.

N.R. Walker
June, 1987

FOREST MANAGEMENT
DEMONSTRATION NOTE NO. 8

Experimental Seeding in 1920 Produces Overstocked Stands of White Spruce; Jack Pine Destroyed by Hares

On June 17, 1920 an experimental seeding of white spruce and jack pine was conducted at the Grandview Ranger Station in the southeast corner of the Duck Mountain Provincial Forest (Figure 1). Three, 0.01 ha plots were seeded to white spruce at a rate of 1.12, 2.24, and 3.36 kg/ha and three plots, of similar size, were seeded to jack pine at a rate of 2.24, 3.36 and 4.48 kg/ha. The experiment was to determine the amount of the seed required to establish well stocked stands of spruce and pine, and to compare the development of the two species on the same site.

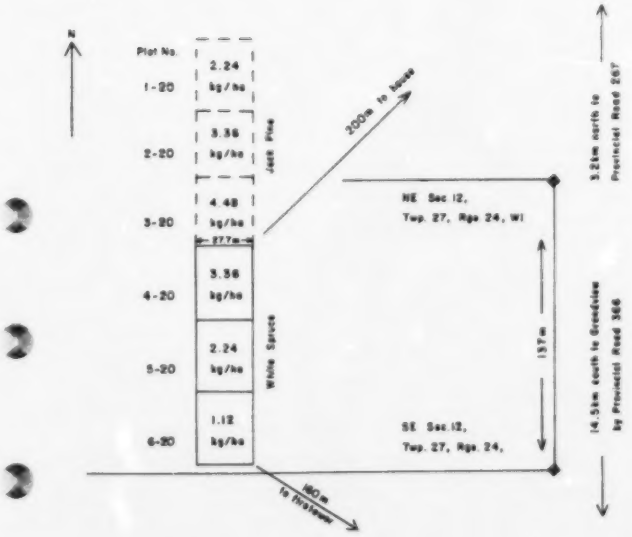

Figure 1. Location of pine and spruce plots seeded in 1920.

The study area previously supported a scattered stand of small aspen, birch and willow. The trees and shrubs were removed and the area was disced six times. Seed was broadcast by hand and the area was then harrowed twice to cover the seed. The soil is a sandy clay loam. The moisture regime varies from 1 to 2 and the pore pattern is 4 (Hills, 1952). The soil profile was described by Haig (1959):

A_o – about 0.6cm of needle litter
A1 – about 2.5cm of black loam
B – about 15.0cm of dark brown structureless loam, and
C – a yellowish brown sandy clay loam with some stones present.

May to September precipitation in 1920 at Dauphin, 48km southeast of the plots, was 5cm below normal. At the plots, this value may have been lower since the investigator noted that in 1920 that "the weather was unusually hot with dry winds, and no rain fell until August 31st." On October 26, 1920, scattered patches of one to four jack pine seedlings were reported for plots 1-20, 2-20 and 3-20. By 1921 the jack pine plots were heavily stocked but, on the white spruce plots scattered groups of one to four seedlings were first recorded in 1922 (Table 1). No explanation can be given for a two year delay in white spruce germination. Haig suggested that the smaller spruce seedlings may have been overlooked. Notes made for the jack pine plots in 1921 stated that tall grass regrowth had taken place and the young seedlings were very difficult to find.

High jack pine seedling mortality from 1921 to 1923 can probably be attributed to the grass competition. In 1924 the terminals of the taller pine and spruce were browsed by snowshoe hares. Pine seedling density in 1925 on two plots is greater that in 1924. This probably can be attributed to the recovery of browsed seedlings classified as dead in 1924. In 1929, willow suckers were reported to be retarding the growth of the pine but not of the spruce.

The next peak of the hare population cycles occurred in 1933 and again in 1943 (Gill, 1958). Severe browse damage was reported in 1933 and jack pine was eliminated from two of the three plots by 1946. The early suppression of the pine by willow to 1929, and trembling aspen ingress would have increased the time period during which the seedlings were subject to hare browsing.

Natural spruce regeneration occurred on all of the jack pine plots and similar ingress would have occurred on the spruce plots but there was no way of measuring this figure. The seed originated from a few adjacent mature trees and the seedlings were established while seedbed conditions were still favourable from the initial

TABLE 1. Periodic per hectare stocking of jack pine and white spruce sown in 1920.

			Year and month of measurement							
Plot	Species	Seed sown kg/ha	1921 Oct.	1923 Oct.	1924 Nov.	1925 May	1929 Sept.	1946 July	1957 Aug.	1986 April
1-20	Pine	2.24	107 637	11 960	2 397	15 542	7 882	74	59	10
2-20		3.36	29 652	11 960	2 397	5 066	10 057	0	0	0
3-20		4.48	49 420	11 960	35 879	27 502	13 319	0	0	0
6-20	Spruce	1.12	0	53 818	35 879	27 507	9 448	9 587	11 762	5 574
5-20		2.24	0	53 818	35 879	40 663	12 677	8 204	8 442	3 524
4-20		3.36	0	53 818	35 879	27 507	17 297	9 093	12 252	5 019

TABLE 2. White spruce and trembling aspen ingress into the 1920 jack pine and white spruce seeded plots.

Ingress species	Seeded species	Plot no.	Ingress (no. per hectare)			
			1929	1946	1957	1986
Spruce	Pine	1-20	1 631	494	474	744
		2-20	544	109	108	337
		3-20	815	544	208	274
Aspen	Pine	1-20			949	1 240
		2-20			3 129	1 687
		3-20			514	638
Aspen	Spruce	6-20		988	1 087	577
		5-20		1 186	103	107
		4-20		3 262	103	107

TABLE 3. Stand development of white spruce sown in 1920.

		Plot	Seed sown kg/ha	Year of measurement 1924	1929	1946	1957	1986
Avg. height	m	6-20	1.12	0.06	0.30	2.80	6.95	13.65
		5-20	2.24	0.06	0.24	2.96	6.22	13.56
		4-20	3.36	0.06	0.21	2.82	5.49	13.29
Avg. diam.	cm	6-20	1.12			2.5	6.1	11.2
		5-20	2.24			3.0	6.4	11.9
		4-20	3.36			2.5	5.8	11.4
Basal area	m^2/ha	6-20	1.12				35	56
		5-20	2.24				26	38
		4-20	3.36				32	51
Total volume	m^3/ha*	6-20	1.12				135	376
		5-20	2.24				90	241
		4-20	3.36				105	318
Merch. volume	m^3/ha**	6-20	1.12				45	284
		5-20	2.24				8	182
		4-20	3.36				18	238

* Table 150 (Dom For. Serv., 1948)
** Table 24 (Kabzems, 1971)

treatment. Spruce ingress into the pine plots was first recorded in 1929 (Table 2). Density of aspen ingress was not recorded until 1946. The spruce plots in 1957 and 1986 were unaffected by the aspen.

In 1986, only one jack pine tree was found on the one plot that had surviving trees in 1957. This tree had a narrow crown and a fresh basal scar where deer had removed the velvet from their antlers; at 15m in height and 14.2cm dbh it is codominant with the surrounding trembling aspen and white spurce. The white spruce was able to recover from the hare browsing and currently the stands are all overstocked. No correlation existed between sowing rate and stocking density in 1986. Measurements made in 1929 were the only ones that showed increasing density from the lowest to the highest seeding rate for both species. A greater variation of sowing rate between plots may have produced more consistent periodic trends. The mean white spruce height, 65 years after sowing, ranges from 13.3m to 13.7m and diameters from 11.2cm to 11.9cm (Table 3). Plot 6-20, with the highest density, has the smallest mean diameter, the tallest trees and the greatest volume.

The site preparation and seeding method employed in this study was very successful in establishing fully stocked stands of jack pine and white spruce. However, two severe browsing by snowshoe hares within a ten year period from 1924 to 1933, and again in 1943 resulted in the complete failure of the jack pine plots. White spruce was able to recover from severe terminal damage, growth was reduced, but no noticeable stem deformity resulted. The high density has produced straight stems and narrow crowns. Live limbs begin at about the 9 m level with dead limbs persisting to the ground, and a few trees have some whipping damage due to the close spacing.

Seeding is currently being used on an operational basis within Manitoba. The method employed in this study is therefore of interest. Seed germination and seedling establishment was enhanced by incorporating the seed into the disced ground by harrowing, where most of it remained dormant, but protected during the first year with low precipitation. Reforestation by seeding, if mechanically broadcast from the ground or by air, deposits the seed on both receptive and unreceptive seedbeds, and while on the surface it is subject to predation by birds and rodents, or it may be carried from the site by high winds. Past seeding studies carried out throughout the province have shown that mineral soil or humus are the most receptive seedbeds (Hennessey, 1968; Waldron, 1966). Operational seeding would be ensured of greater success if seeds were placed only on the most favourable seed-

beds and then lightly covered by a small amount of mineral soil. Hand seed placement and covering with mineral soil would be more costly and labor intensive, but this method would still be faster and less expensive than reforestation by planting.

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Hennessey, G.R. 1968. Early survival and growth of planted and seeded white spruce as affected by seedbed types occurring on scalped strips prepared in aspen stands. Manitoba Dept. For. Rural Dev., Can. For. Serv., For. Res. Lab., Wpg., Man., Int. Rpt. MS-70.

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N.R. Walker
Jan. 1988.

FOREST MANAGEMENT
DEMONSTRATION NOTE NO. 9

Burning for Black Spruce Regeneration on a Lowland Cut-Over Site in Southeastern Manitoba

Two experimental burns (May, 1967) were tested on a peaty, very moist lowland site in southeastern Manitoba to improve seedbeds and black spruce regeneration after cutting (Fig. 1). The

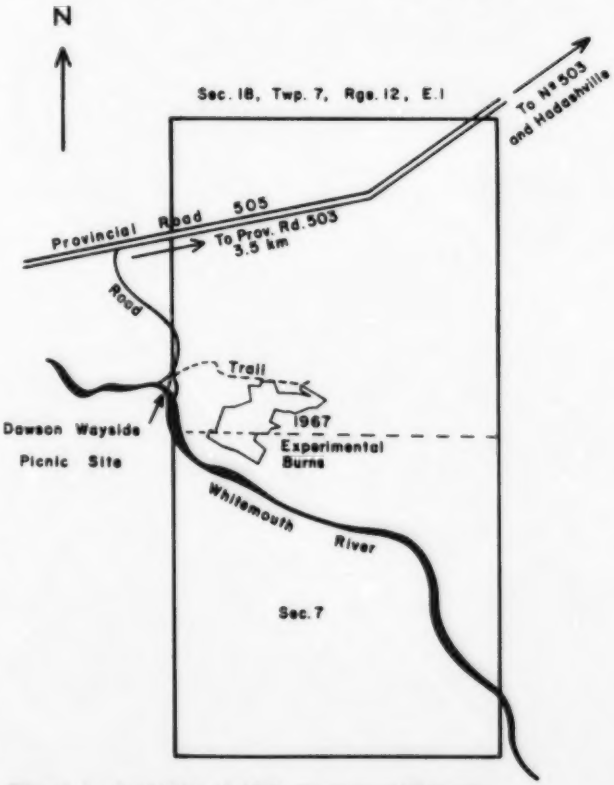

Figure 1. Location of 1967 experimental burns.

operations were conducted under different degrees of desiccation in the upper peat materials so that light (2.4 ha) and moderate (3.6 ha) burns were obtained (Fig. 2). Most of the resulting seedbeds (95 % by area) consisted of partially burned peat and only some of them (5 % by area) had unburned moss and litter. Unmerchantable trees that were left standing at the time of cutting constituted the main seed source of each of the burns. After five growing seasons, black spruce stocking by 4.047-m^2 quadrats was 94 % on the moderate burn, 70 % on the light burn, and 35 % on the control. The numbers of seedlings associated with this stocking were 39 856, 7 598, and 4 690/ha, respectively. (Chrosciewicz 1976) Since then, the spruce has developed well and it is gradually overcoming hardwood competition.

The experiment clearly demonstrated that burning can be successful in regenerating black spruce on lowland cut-over sites. There are, however, two basic requirements that must be met. First, an adequate seed source must be available to provide proper seed dispersal after burning. This can be assured at the time of harvest cutting by leaving all residual trees standing (Chrosciewicz 1976) or by clear-cutting about 100–m–wide strips with seed sources on both sides (Johnston 1971). The second requirement

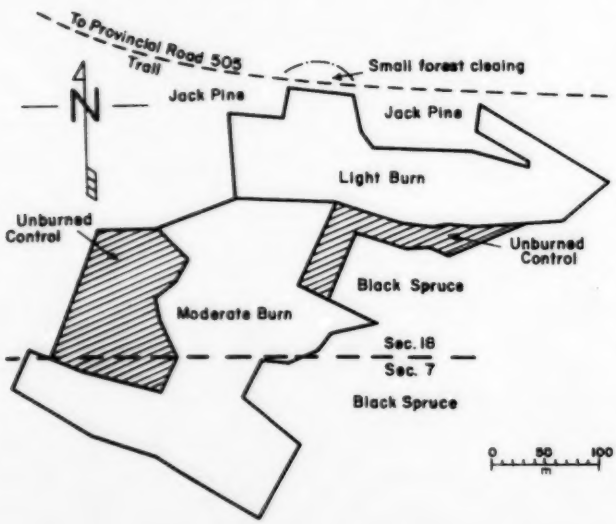

Figure 2. Light and moderate burns with unburned controls.

is that fuels such as slash, litter, feather moss, and the upper peat materials must be sufficiently dry to allow reasonably deep burns. (Chrosciewicz 1976).

Various seedbed, regeneration, and plant-succession characteristics have indicated beneficial effects of burning. Specific guidelines for the postcut treatment by prescribed fire on other black spruce lowlands can be found in Chrosciewicz.(1976) For best results, future burns should be conducted under reasonably similar site, fuel and weather conditions as those originally described.

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Chrosciewicz, Z. 1976. Burning for black spruce regeneration on a lowland cutover site in southeastern Manitoba. Can. J. For. Res. 6:179-186.

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Z. Chrosciewicz
January, 1988.

FOREST MANAGEMENT
DEMONSTRATION NOTE NO. 10

Scarification in 1966 Produces Densely Stocked Areas of Natural White Spruce

In the late summer of 1966, portions of a 65 ha area, located on the former Canadian Forestry Service experimental area within Riding Mountain National Park, were scarified with a bulldozer, using a straight blade, to promote natural regeneration of white spruce (Fig. 1, Area 1). The scarification was conducted in natural openings between mature, undisturbed stands of spruce and poplar that had previously supported little white spruce regeneration. The straight blade scalping operation removed all vegetative ground cover and any trees, if present, to create continuous mineral soil seedbeds varying from about 0.1 ha to 1.0 ha in size. The surrounding stands of white spruce provided sources of natural seedfall. Once the scalped areas were fully regenerated to white spruce seedlings the mature spruce stands were to have been commercially logged. As a result of the closure of the Manitoba-Saskatchewan District Laboratory in Winnipeg in 1970, the logging operation was never carried out.

Prior to scarification, on August 12, 1964, the area was aerially sprayed with 2, 4-D herbicide, to kill the hardwoods such as trembling aspen and balsam poplar. This operation was intended to reduce heavy leaf fall that can smother small white spruce seedlings, and to create a habitat that would allow free seedling growth (Pratt, 1966).

Soils in the area were slightly to moderately calcareous clay loam tills. The moisture regime varied from fresh to moist.

In 1965, one year after the 2, 4-D herbicide application, an assessment was made of its effectiveness. (Pratt, 1966) Severe top kill occurred on about 75% of the mature hardwoods. The herbicide effect was the most severe on the trembling aspen, then the white birch and then the balsam poplar. Trembling aspen suckers (6 523 stems/ha) and hazel (56 339 stems/ha) were eradicated from the area, but little damage occurred to rose, raspberry, current species or balsam poplar suckers. All aspen and balsam suckers were less than 2 m in height. In 1987, numerous well-rotted aspen logs were on the ground, indicative of extensive mortality since treatment. Some of these logs had broken off at stump height while others had broken off up to 10 m above the ground. Live individual, and pockets of mature trembling aspen and balsam

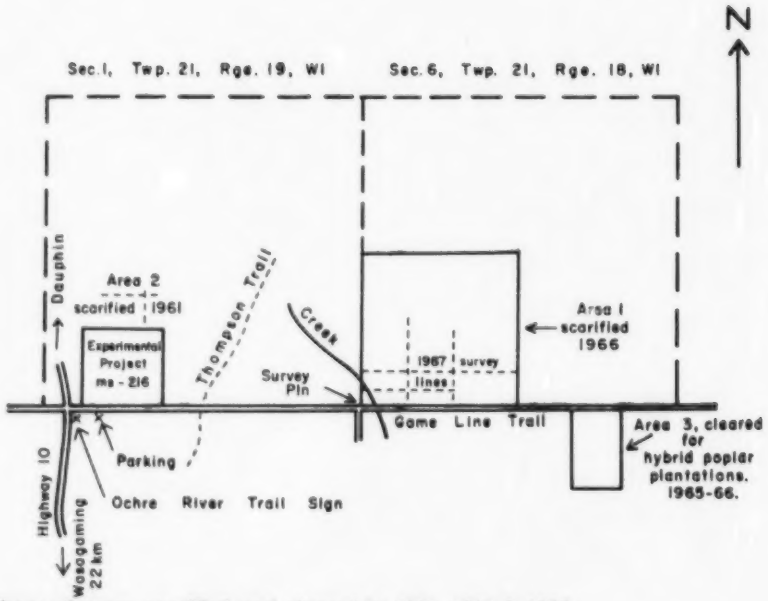

Figure 1. Locations of areas scarified and cleared in 1961, 1965 & 1966.

poplar that survived the herbicide treatment were still scattered throughout the entire area.

In 1987 a linear survey of 1 770 m indicated that 18% of the 65 ha block was scarified to mineral soil, 4% was covered with topsoil and debris resulting from the treatment, and 78% was undisturbed. Stocking to white spruce on the scarified portions is 96% and density is 133 809 stems/ha (Table 1). No white spruce regeneration was found on the debris piles. In 1969 the number of white spruce on the scarified areas averaged 38 300/ha and 1 050/ha on the unscarified (Pratt, 1970). Mean height to the end of the 1986 growing season of the tallest spruce sapling measured in each stocked quadrat was 1.47 m and overall heights ranged from 0.36 m to 3.08 m. The mean height increase over a three year period from 1983 to 1986 was only 0.46 m.

Larch stocking was only 17% but good growth and reproduction was noted for this species. When a seed source was in close proximity to the scarified area numerous larch seedlings were found and frequently seedlings were present when no mature trees were readily visible.

By 1969 trembling aspen suckers were again well established on the scarified areas. Aspen density was 7 549 stems/ha and balsam poplar 684 stems/ha (Pratt, 1970). In 1987 stocking to aspen and balsam poplar was 63% but density was only 952 stems/ha. Browse damage occurred to 82% of the aspen and poplar suckers. Similar browsing by elk and moose has prevented the regrowth of an aspen/balsam poplar forest on a comparable area that was specially treated to promote its regeneration (Walker, 1987).

Twenty growing seasons after treatment, the scarified areas are heavily stocked to white spruce but growth has been slow. One cause of poor growth can be attributed to periodic flooding and water ponding in deeply scalped areas. White spruce regeneration located on these areas generally has a pale chlorotic appearance. The tallest saplings were usually located within two meters of the unscalped portions where they appeared to be taking advantage of available nutrients in the adjacent undisturbed topsoil.

Area 2 was a portion of a 93 ha area similarily scarified, but not herbicided, throughout Section 1-29-19 with a straight bulldozer blade in 1961 to promote natural white spruce regeneration (Fig. 1). No measurements were taken on this area but observations in 1987 showed that the area was well stocked to vigorous and healthy white spruce. Young white spruce saplings 3.5 – 4.5 m tall with diameters ranging from 5-7 cm were well distri-

TABLE 1. Stocking, density, and height of regeneration on Area 1 – scarified 1966

Species	Stocking %[a]	Density per ha[b]	Mean ht. 1983	(m)[c] 1986	Std. dev. of ht. 1986
White spruce	96	133 809	1.01	1.47	0.57
Larch	17	4 762	–	2.51	1.19
Trembling aspen/ balsam poplar	63	952	–	0.91[d]	0.42

a Based on 216 quadrats 4.05 m^2.
b Based on 21 quadrats 1 m^2.
c Tallest seedling on stocking quadrat.
d 82% of seedlings browsed.

buted throughout the scarified areas. The improved growth and health of these young trees when compared to the white spruce regeneration on Area 1 is attributed to less organic soil removal and a less compact growing medium within the remaining humus layer.

In view of the regeneration success achieved on Area 2, the aerial spray operation with 2, 4-D herbicide on Area 1 (to control aspen leaf fall and the smothering of small white spruce seedlings) was an unnecessary precaution. While seedling mortality by aspen leaf fall may well be a problem in smaller forest openings or in strip bulldozing, the relatively large 0.1 ha to 1.0 ha open areas created by scalping minimized any smothering problems. In another study, aspen, white birch, and shrub leaf fall on 2 m wide bulldozed-scalped strips alternating with 6 m wide undisturbed areas within dense aspen stands was 2 067 kg/ha on the 2 m treated strips (Waldron, 1964). The leaf area was sufficient to cover the entire ground surface 2.71 times and cause seedling mortality.

Mineral soil or humus is a required seedbed for natural regeneration of white spruce (Hennessey, 1968; Waldron, 1966). Scarification-scalping with a straight bulldozer blade exposes good mineral soil seedbeds and also controls competing vegetation for a number of years. The contrasting growth between Area 1 and 2, however, shows that straight blading requires a careful and skilled operator so that just the right amount of topsoil is removed.

As an alternative to straight blading, a machine that provides individual scalped spots (Lowman and Birch, 1987) or a disk trencher that exposes mineral soil along narrow periodic or continuous tracks could provide sufficient microsites for natural regeneration. However, competing vegetation that would rapidly overtop the seedlings would have to be controlled to permit free growth. On small scalped areas the topsoil with its nutrient supply would be immediately available to the seedlings and deeply scalped areas that allow water ponding and flooding would be minimized.

In 1965 and 1966, within 1 km of Area 1, a 10 ha block was cleared and bladed, with the residue piled in windrows, to prepare the area for hybrid poplar research plantations (Fig. 1, Area 3). Only a small portion of this area was planted to hybrid poplars. The entire area is now well stocked to natural white spruce regeneration. In 1987 the white spruce regeneration on this site was very badly damaged by a probable combination of frost and winter drying, but little damage had occurred to the white spruce regeneration on Areas 1 and 2. This suggests that frost and desiccation damage to young white spruce can be minimized by limiting the size of openings in a mature spruce/poplar forest to one ha or less.

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N. R. Walker
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